HUECKEL

Modern Methods of Wood Preservation

Civil Engineering

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MODERN METHODS OF WOOD PRESERVATION

BY

ALBERT PHILLIP HUECKEL

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

ALBERT PHILLIP HUECKEL

ENTITLED MODERN METHODS OF WOOD PRESERVATION

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

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INTRODUCTION.

The idea of the preservative treatment of wood is by no means new. Timber was naturally the first material employed by man for the purposes of constructive engineering. Allusions to various substances employed for preserving timber and other vegetable fibers from decay are frequent in the writings of the ancients. Tar and pitch have been used for painting or smearing wood from periods of the most remote antiquity. The magnificent statue of Zeus by Phidias was erected in a grove at Olympus where the atmosphere was damp; the wooden platform upon which it stood was therefore imbued with oil. Glauber in 1848 published two methods of treating wood. The first patent on preservative processes in England was issued in 1737. During the 18th century some ten different methods of treatment were proposed. In America between the years 1837 and 1890, 269 patents were granted on methods or materials for the preservation of wood. Since 1890 many patents have been granted for methods having for their principal object economy, such as the Rueping process.

Active progress in timber preservation dates from the year 1832. During this and the ten following years, the processes invented by Kyan, Bethell, Burnett and Boucherie were introduced in England and France, and shortly put into very general use. The Bethel patent related more particularly to the method of treatment. This consisted of the use of closed vessels to contain the timber, in which first a vacuum was produced, then fully surrounded by the chemicals and pressure applied to force it into the wood. The other treatments advocated different chemicals.

The history of such treatment in the United States extends

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about as far back, but the adoption of treatment has not been as general. For this there has been good reason. Our supply of timber being much greater, and the quantities required greater while the cost has been much less, the necessity for the conservation of the supply and the economy of an expenditure for treatment, has not been sufficiently evident. In recent years, however, no subject has received closer and more earnest consideration than that pertaining to the use of wood preservatives and their application to timber used in the construction of marine work, railroads, etc. This has been brought about by various causes chief among them being the denudation of the pine and oak forests of the north, the advance in the cost of timber, the desire of builders to erect more permanent structures and improvements than formerly were the rule.

The United States uses each year over 100,000,000 cross-ties of which about 18 percent are treated, and about 80 percent of this number are used for renewals. Practically all of the ties treated were the cheaper soft wood, such as loblolly pine, long-leaf pine, short-leaf pine, hemlock pine and tamarack; the hard pines, the oak ties, and the redwoods seldom being treated. There are 800,000 miles of telephone poles in use in this country. This means that at least 32,000,000 poles are in service. The untreated poles have an average life of twelve years. For the maintainance of the present lines, 2,650,000 poles are required annually. There are no figures showing how many of these poles are treated, but the number is small. The total consumption of the timber in this country per year is about 100 billion feet board measure. Such a drain upon our forests would consume all our timber in 20 years, excluding the annual growth, which does not exceed over 35 billion feet. From these statistics it is evident that we must prolong the life of the

timber used, by preservative processes. It is with these processes that this paper has to deal.

CAUSES OF DECAY IN TIMBER.

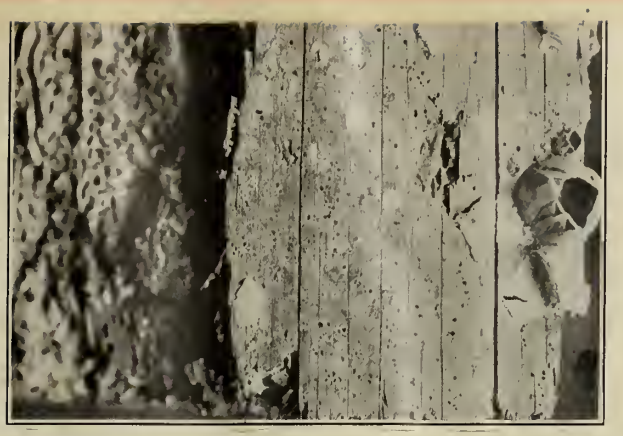
Decay in timber is brought about through the presence, growth and development of living organisms known as bacteria and fungi. Insects and teredos bore holes into the sound timber, and in many cases they may riddle a stick completely, so that it falls to pieces. The work of the white ants and the teredo which are so destructive to all timbers in warmer climates and the southern sea waters respectively, are of this character. Timbers which are submerged in ocean water seldom deteriorate from the ordinary organisms which cause decay, but are subjected to injury from other sourses.

Three varieties of ship worms, teredo navalis, teredo norvegica, and xylotrya fimbriata, are extremely destructive in certain localities along the American coast. Considerable injury is also done in some sections by the limnoria and the cherula. The ship worms are mollusks, and form galleries underneath the surface of the timber and completely riddle it. The limnoria and the cherula are crustacean ipsods and attack the timber on the outside, frequently cutting piling in two. The rate of increase among ship worms is almost beyong belief. It has been calculated that one female may contain from 1,000,000 to 100,000,000 eggs. Specimens of the ship worms four feet in length and seven-eighths of an inch thick are abundant along the Atlantic coast from Newport News southward. On account of their vast numbers and great size, the teredo norvegica and the xylotrya fimbriata are almost entirely responsible for the great de-

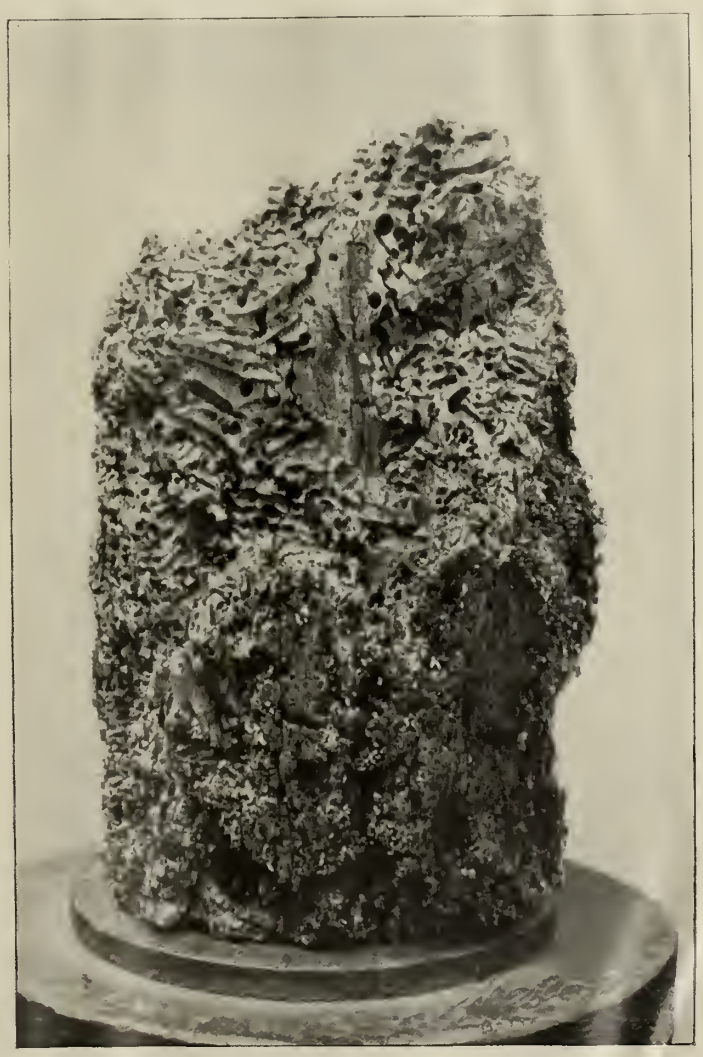
struction done to submerge timbers along our southern coast. The ship worms do not eat the wood, but live on infusoria obtained in it. The wood passes into one of the siphons in the shape of a very fine powder, and, on contraction of this siphon, it is thrown out. The teredo enters the wood through a very small pin like opening, these holes are so small that they may be unnoticed, while inside the wood may be honeycombed. Untreated timbers placed in teredo waters have been completely honeycombed in less than thirty days, while creosoted timbers have lasted over twenty years and were still in very good condition. These facts are shown very clearly in figures on pages 5, 6 & 7.

The decay of structural timber is, however, brought about most frequently by either bacteria or fungi. These organisms require certain conditions for their development. Chief among these conditions are moisture and warmth. Very favorable conditions for the decay of timber exists in the subtropical and tropical regions. It is these conditions which are favorable for the development of the bacteria, and fungi that we must eliminate.

Bacteria and fungi are low plants and grow very rapidly, these plants obtain their food by breaking up the complex chemical compounds; of which wood is composed into simpler substances, utilizing some of these and leaving some either as gases or solids. Briefly stated they take all the food from the wood, and leave a different substance, rotted wood, behind. In the Texas experimental track about one-half of the untreated ties had a fungus growth after two years in service, while only a few treated ties had any fungus growth. The fungus growth on these ties is shown on pages 8, 9 & 10 Thoroughly dried timber or timber kept under water all the time we



Small Pin - Like Holes Indicate where Teredo Entered when Small. Connection is Always Maintained with the Outside through these Small Openings.



No. 3.—UNTREATED OAK PILE AFTER TWO YEARS' SERVICE.

SECTION OF UNTREATED PILE AFTER EXPOSURE IN TEREDO WATER.

The above specimen shows a teredo-eaten pile from near the mouth of the Pascagoula River, after about three years in the water. Some of the holes in this section are three quarters of an inch in diameter.

SECTION OF TREATED PILE AFTER EXPOSURE IN TEREDO WATER.

This section of creosoted pile was taken from a pile in Muscogee Wharf at Pensacola, Fla., after it had been in service for more than twenty years. There is no worse teredo water in the Gulf of Mexico than at Pensacola.

No. 1.—PINE PILE AFTER TWENTY-EIGHT YEARS' SERVICE

FIG. 1.—UNTREATED BEECH TIES WITH A TIMBER-DESTROYING FUNGUS (POLYSTICTUS VERSICOLOR FR.) GROWING ON THE ENDS—AN EVIDENCE OF DECAY.

FIG. 2.—UNTREATED RED OAK TIES WITH A TIMBER-DESTROYING FUNGUS GROWING ON THEM. ONE TIE IS BADLY SPLIT.

FIG. 1.—UNTREATED HEMLOCK TIES WITH A TIMBER-DESTROYING FUNGUS GROWING ON THEM.

[Note that almost all of these ties have fungi on them.]

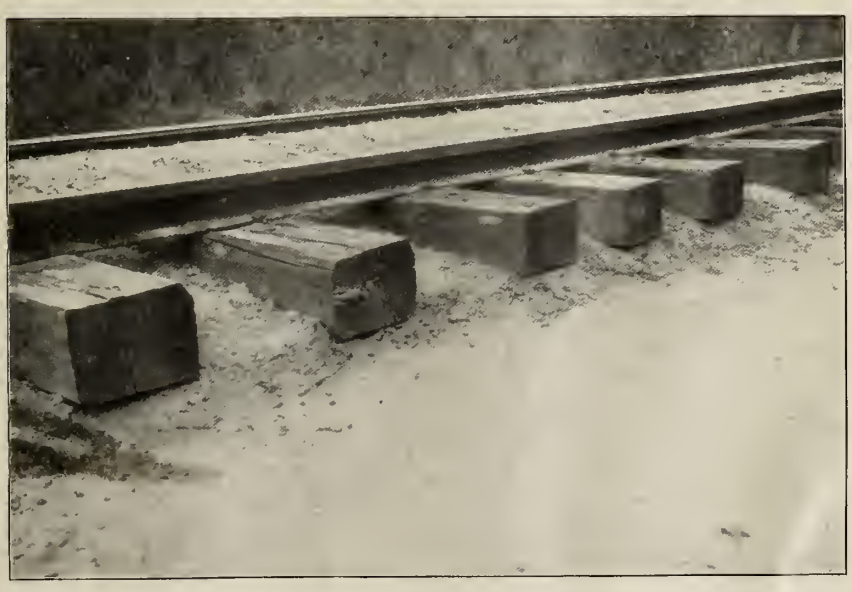


FIG. 2.—UNTREATED LONGLEAF PINE TIES, ONE OF WHICH SHOWS TIMBER-DESTROYING FUNGUS (LENZITES SEPIARIA).

FIG. 1.—UNTREATED LOBLOLLY PINE TIES, SHOWING TIMBER-DESTROYING FUNGUS (LENZITES SEPIARIA) GROWING ON THE ENDS.

FIG. 2.—UNTREATED TAMARACK TIE BADLY DECAYED, SHOWING FRUITING BODIES OF TIMBER-DESTROYING FUNGUS.

know, of course, endures indefinitely. The timbers in many old buildings have been in position for hundreds of years, and do not show any signs of detericration. Timbers that have been placed in the sea in prehistoric ages are still in perfect condition. Here the supply of oxygen necessary for the development of fungi is cut off. Decay in piles for instance, takes place near the point where the pile emerges from the water. In fence posts and telegraph poles the decay usually starts just below the surface of the soil. Above the ground the wood remains dry, while at the extreme base there is only a limited supply of oxygen. Where there is some oxygen and some moisture, that is, near the surface of the ground, there the rot sets in.

A striking feature is the great variability in all respects of timber of the same kind taken from different trees and localities. Those who have impregnated timber are constantly confronted with this fact, for they find "that very rarely are two pieces of wood alike."

On account of the great rapidity of wood decaying and being destroyed by insects, attempts were made to prevent the favorable conditions of the growth of fungi and bacteria, and to prevent insects from boring into the wood. Many centuries ago wood was charred to make it more resistant. Later on came a period when wood was coated with preservative paints, and then attempts were made to inject perservatives into the wood. The theory upon which the injection of salts and oil into the wood is based, is that the preservative acts as poisons, killing the fungi or bacteria which grow in wood, and preventing the destructive insects from boring into the wood.

Today there are many processes to impregnate timber with antiseptics. There can be no doubt there are processes which do increase the length of life of timber, and do so at a reasonable cost. The question which is before those who use timber for any structural purpose is: which one of the numerous processes advocated shall we use? The answer to this question must take into consideration, (1) the cost of the operation; (2) the comparative efficiency of the various treatments; (3) the readiness and ease with which any one treatment can be employed. While the results obtained during the last forty years are beyond question of great value as indicating the extent to which one or another process may be trusted, we have few indications as to the comparative value of these various processes. The results were obtained in particular sections of the country; they are restricted to particular soil conditions of which we have only scant records, and to particular kinds of wood.

Any one who has gone over the published statements of results of timber treatment, can not fail to observe the numerous contradictory statements found in these reports. Voluminous discussions upon this question have appeared every year, and yet there seems to be no well defined understanding of the best method of timber treatment. The difficulty has been that many have tried to compare results obtained with the same or similar processes in different localities under different conditions. It is obviously unfair to condemn a process because it has given poorer results in Alabama than in a Western State. One may be warranted in stating that it may prove economic to employ one system in one place and another in a second part of the country.

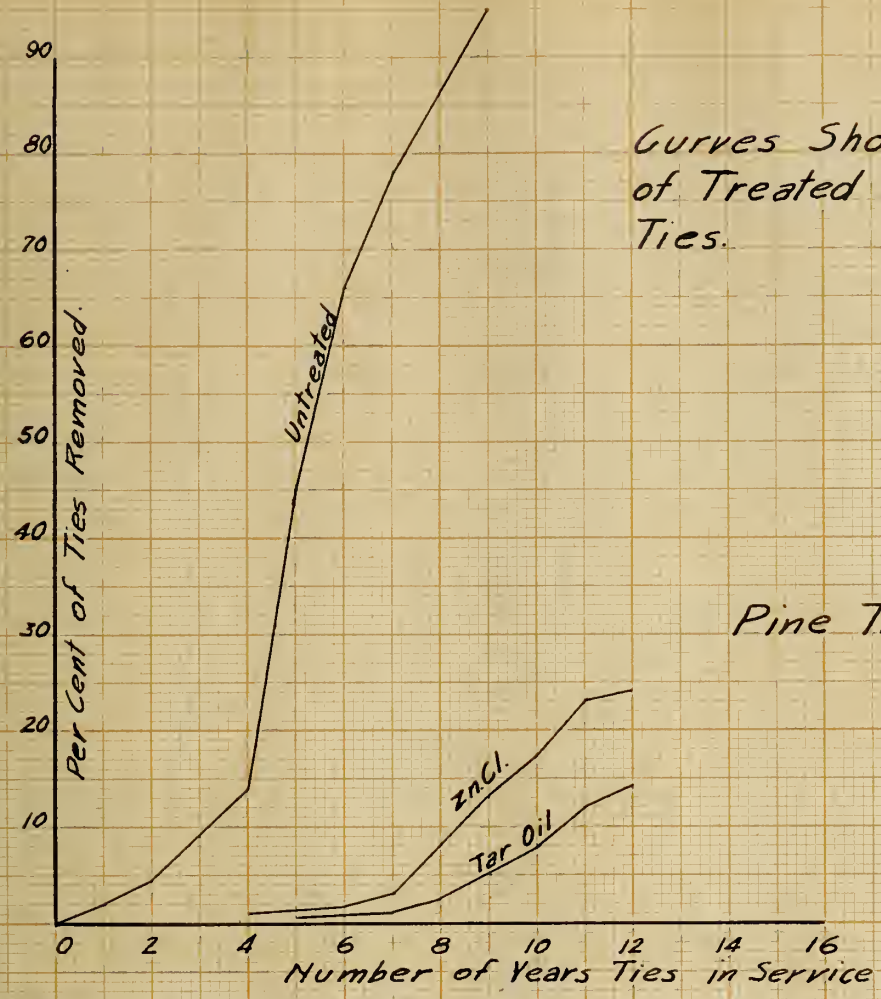
The following will be a brief description of an experiment,

which was begun in 1902, with the intention of getting some data upon the various processes for railway ties. It is well known that treated and untreated timbers decay with greater rapidity in some parts of this country than in other parts. It was thought possible that, by selecting a region where decay took place with the greatest rapidity, the retrogressive changes which take place in timber might be hastened, and conclusions made within a shorter time than if the timbers were laid in a region where decay is slow. A portion of track belonging to the Santa Fe Railroad was finally selected, lying some 75 miles east of Somerville, Texas. The ground in which the timber is placed admits of little drainage. The annual rainfall and the average temperature are high. The track is shaded for some distance. These conditions favor not only rapid changes in the source injected into timber, but also rapid growth of the destructive fungi when once the amount of injected salts had fallen below the mininum. The ties in this portion of the country treated with chloride of zinc had decayed in from two to four years, while untreated timber decayed in twelve to fourteen months. The experiment is outlined with a view of answering these questions: (1) which treatment now advocated gives the best results (under the same conditions) in increasing the length of life of the timber? (2) Does one and the same kind of treatment give the same results with different timber? (3) Can inferior timbers be made to pay for the cost of renewal by impregnating them with one preservative or another? This experiment is to be regarded as a first step, which may answer most of the unsolved questions now awaiting answers. At the present time the general condition of the track was good. Almost all of the untreated timbers showed signs of decay after two years of service. The treated ties are in good condition especially those

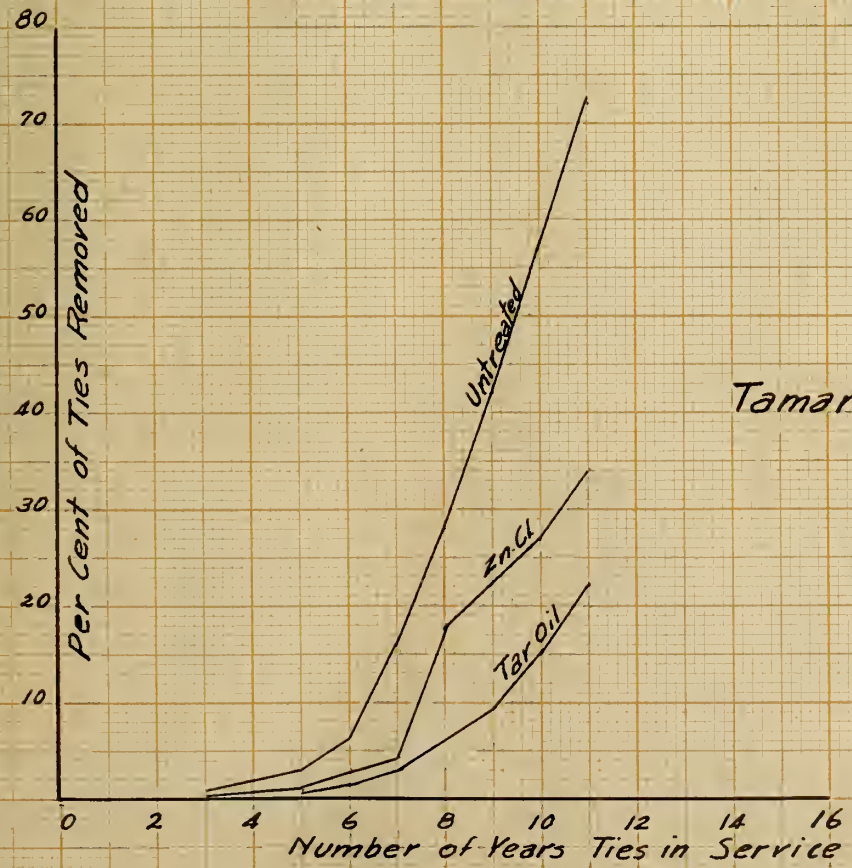
treated with creosote. The most interesting result so far obtained from the test, is that all the ties which were subjected to excessive heating during the treatment, had to be removed very soon after being placed, on account of there brittleness and being shattered to pieces. This effect due to excessive heating is described more fully under the effect of steaming. Views taken twenty months after the track had been laid, are shown on pages 8, 9, & 10

Very good and accurate records have been kept in Austria concerning the life of untreated and treated ties under the same conditions. These are shown by the following diagrams on pages 15 & 16

Curves Showing Removal of Treated and Untreated Ties.



Pine Ties



Tamarack Ties

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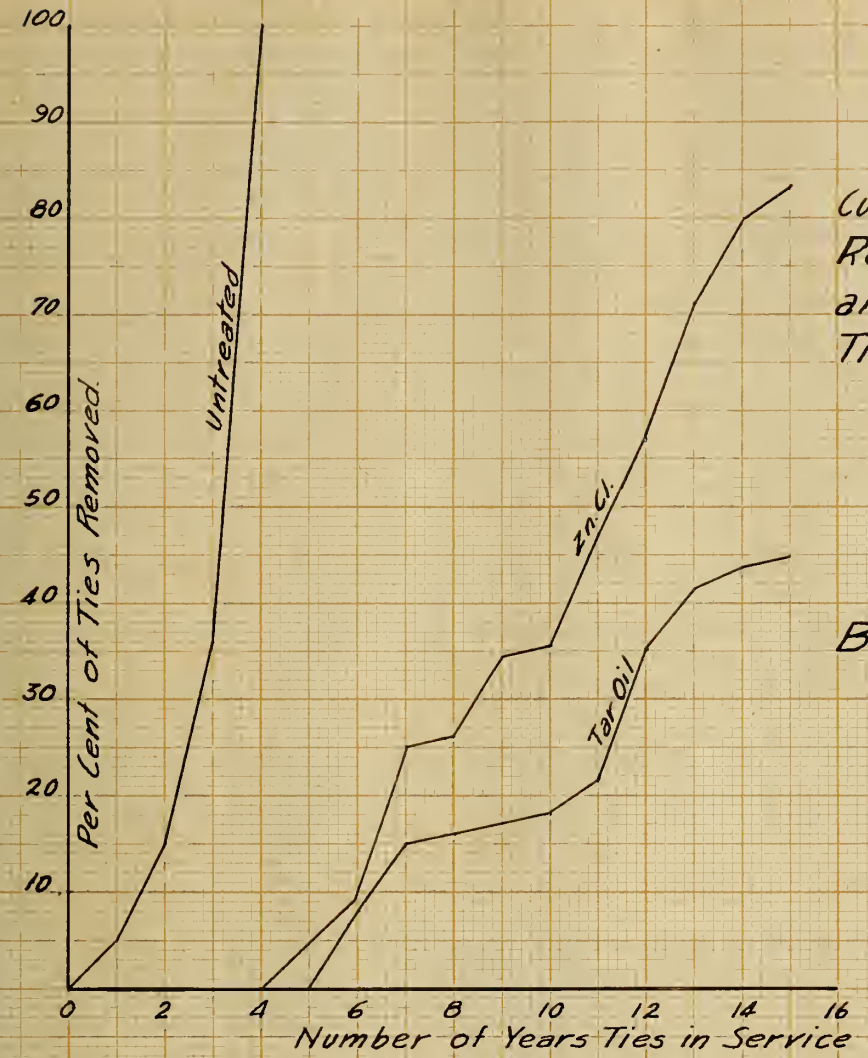
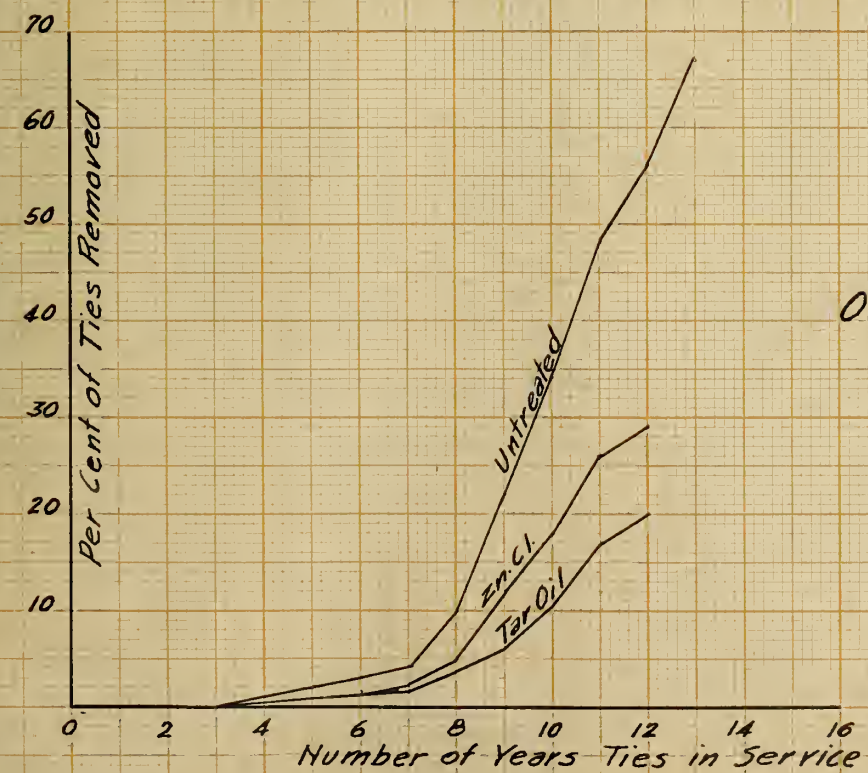


Curves Showing Removal of Treated and Untreated Ties

Beech Ties



Oak Ties

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From these diagrams one may conclude that oak ties last twelve to fourteen years, that when treated with zinc chloride they give a much longer service , and still more when treated with tar oil. The beech ties give a very striking picture of the comparative results and needs little comment. The unimpregnated timber was all gone after four years. The ties treated with zinc chloride lasted on an average of eleven to twelve years, and those impregnated with tar oil over fifteen years. The results of the tamarack ties may be given as follows: unimpregnated, nine to ten years; impregnated with zinc chloride, probably thirteen years; impregnated with tar oil over fifteen years. The pine ties are among those which decay most rapidly. It will be noted from figure that untreated pine ties last about five to six years, and the treated ties will last many more years. The curves do not extend out far enough, but they show a probable average life of over seventeen years for the zinc chloride treatment and considerable more for the tar oil.

A comparison of the diagrams, show that treatment of timber with zinc chloride increases the length of life of treated timber very materially, and treatment with tar oil does so still more. These results were obtained in Austria and in comparing them to our timbers, it will be found that the oak is an unusally resistant timber, the others however are about the same as in this country. The lengthening of life of tamarack ties is much like that of the oak. The results obtained with the tar oil considerably exceed those shown with zinc chloride. A glance at the curves will suffice to show this without any further comment.

PROCESSES OF WOOD PRESERVATION.

There are two general methods of impregnating wood with a preserving antiseptic.

(1) Open Tank Method

(2) Closed Tank Method

The open tank method is based upon the use of an open tank capable of withstanding heat, and either equipped with steam coils or so arranged that fire can be placed underneath it. This method has not been used to preserve wood on a commercial basis, but has been mostly used by the United States Forest Service in performing experiments to determine some practical method of prolonging the life of timbers, part of which are to be in the ground, such as fence posts, telegraph and telephone poles. The idea is to treat the part that is to be below the ground surface, and to leave the part above ground untreated, hence making a pole with all parts of a more equal life.

Sufficient preservation is run into the tank to cover the portion of the timber which is to be treated, and the temperature of the liquid is then raised slightly above the boiling point of water. This temperature is maintained for a length of time depending upon the character of the wood and the treatment desired. At the end of the hot bath the timber is either quickly transferred to another vat, containing a cold preservative, in which it is submerged for a definite period of time, or else the heat is shut off and the timber is allowed to remain in the cooling liquid, until the required absorption is obtained, or until no further absorption takes place. The time required by the treatment is from 14 to 18 hours, it may be shortened, however, without transfering the timber from-

one vat to another, by running out the hot liquid at the end of the hot bath and simultaneously letting in the cold liquid.

The second method was introduced in 1831 by Mr. Breant, a director of the Mint of Paris, who invented the first apparatus for injecting timber by means of vacuum and pressure, in a closed iron cylinder. The cylinder was fixed vertically, and inconvenient arrangement not necessary to the efficiency of his process. The iron cylinder and the process by vacuum and pressure were adopted by Mr. Bethell in 1838, and greatly improved by him and by Mr. H. P. Burt, who were associated together for some years. The cylinder was enlarged, its fittings strengthened and simplified, and an interior heating apparatus added. The main features of this machinery are still the same in the usual apparatus of the present day.

The present method of treating timber by the vacuum and pressure tank consists of loading the seasoned or unseasoned timber (depending whether the timber is seasoned in a storage yard or by the steaming process) on buggies made entirely of metal and run directly into the retort. These retorts are usually six feet in diameter and 125 feet long, and will accomodate about 2100 cubic feet. The largest retort now in use is the one used by the International Creosoting and Construction Company, of Galveston, Texas, it has a diameter of 9.5 feet and is 165 feet long with a capacity of about 7500 cubic feet. The retort contains tracks on which the train cars (which are made entirely of iron) run, the gauge of which is the same as that of the train yard tracks, by means of which the charge is run in and out. These retorts are provided with a strong door, self-sealing, or may be hand-bolted as may be desired,

fitting tightly to resist pressure and to prevent leakage and waste. The heating apparatus consists of from 8 to 14 lengths of 1 1/2" steam pipes, running underneath the track over which the train of loaded buggies passes, and in the best plants some pipes are placed on the sides of the retort. The plant must be further equipped with a vacuum pump, air compressor, force pump, large tanks for the various solutions and other detail appliances. The following views on pages 21, 22, 23 & 24 show the massive construction of the cylinders and doors, also show the heating apparatus and the iron buggies.

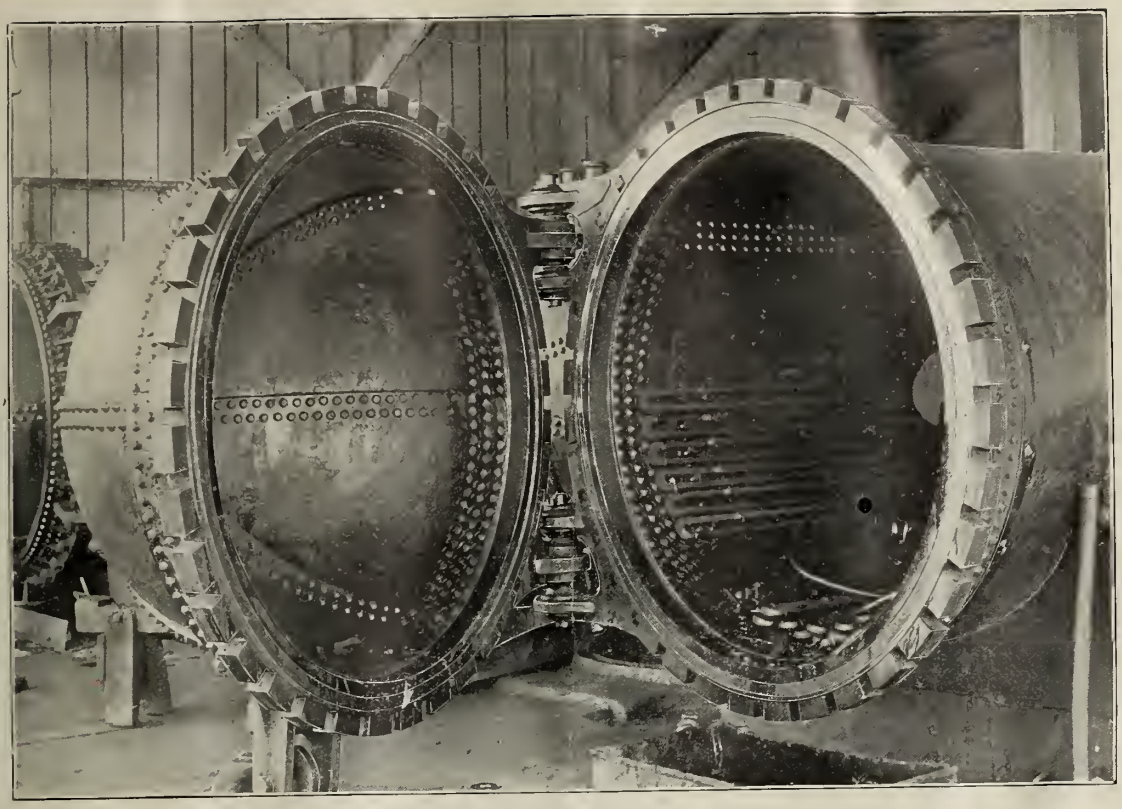
The treatment of wood consists of two distinct divisions:

First. Steaming

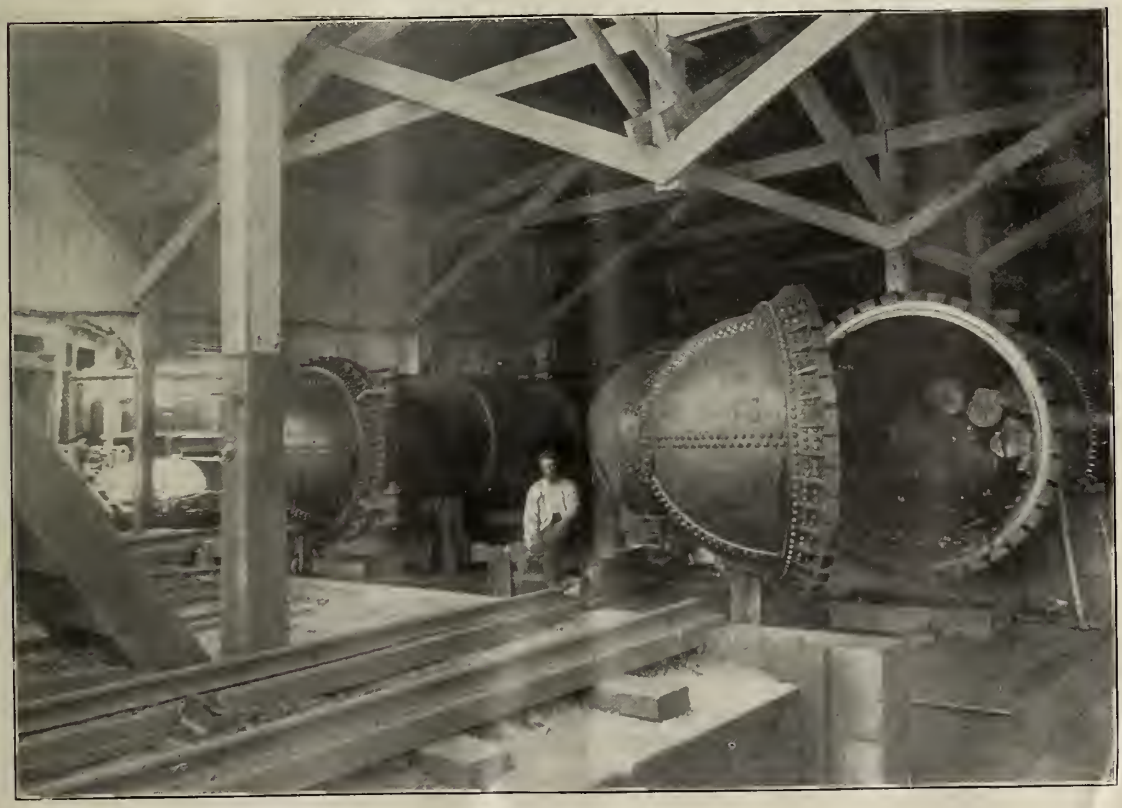
Second. Impregnation with an antiseptic

The first and most essential thing is the seasoning of the timber. Unless the wood is thoroughly and properly seasoned, the work and cost of treating will be ineffectual. All fermenting properties in the wood such as water, resins and starches must be removed, and their places supplied with an antiseptic or the remaining portion will ferment, causing dry rot which will destroy the durability, life and strength of the timber.

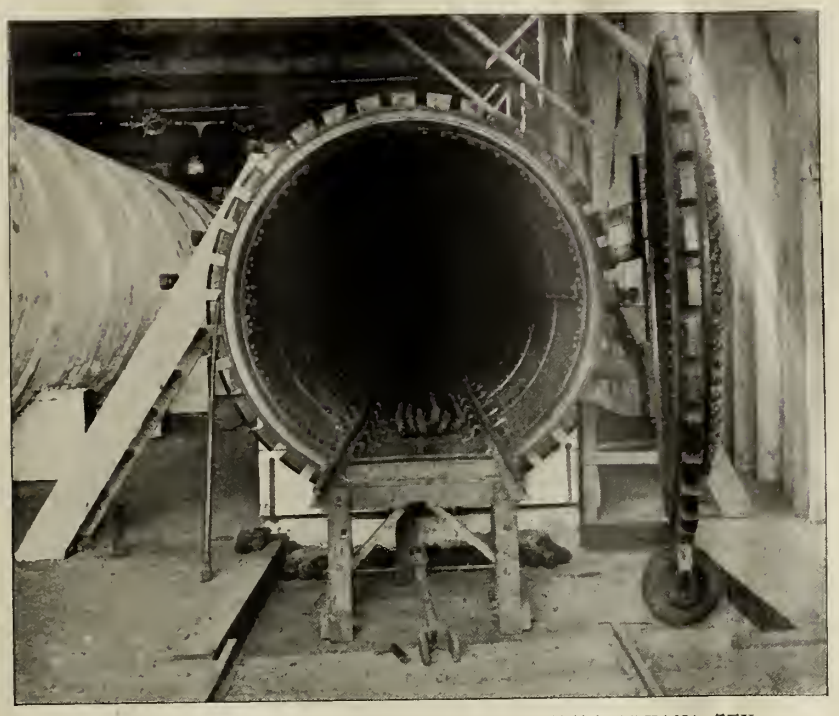
Seasoning is accomplished in three general ways, steaming, air drying and kiln drying. The method usually practised in this country is the seasoning of the wood by the steaming process. The timbers are placed in air tight cylinders, which have been already described, and a partial vacuum of about 24 inches is maintained for from 15 to 20 minutes. Live steam is then applied, at about 30 lbs., for four to five hours with a temperature not to exceed 250 Fahr: After this steam pressure has been maintained the required length



END OF CYLINDER OPEN.
This view shows the massive construction of the doors and cylinders.



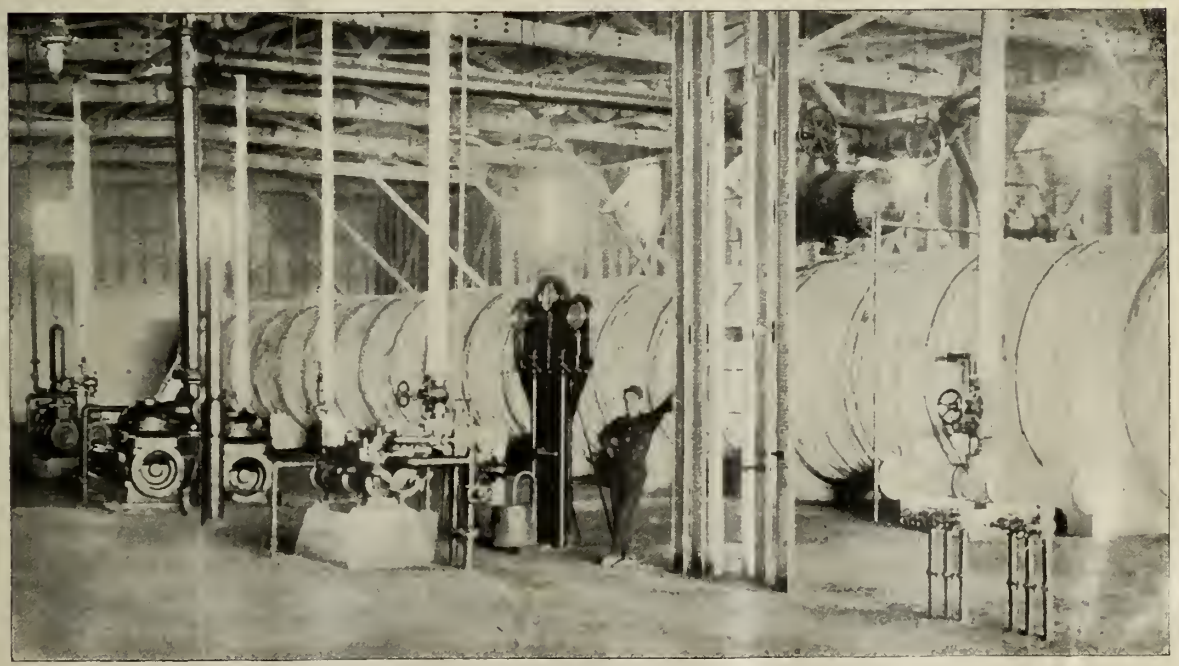
CREOSOTING CYLINDERS.
The middle cylinder is 105 feet long and the outside ones are 120 feet long.
They are of steel, five eighths of an inch thick.



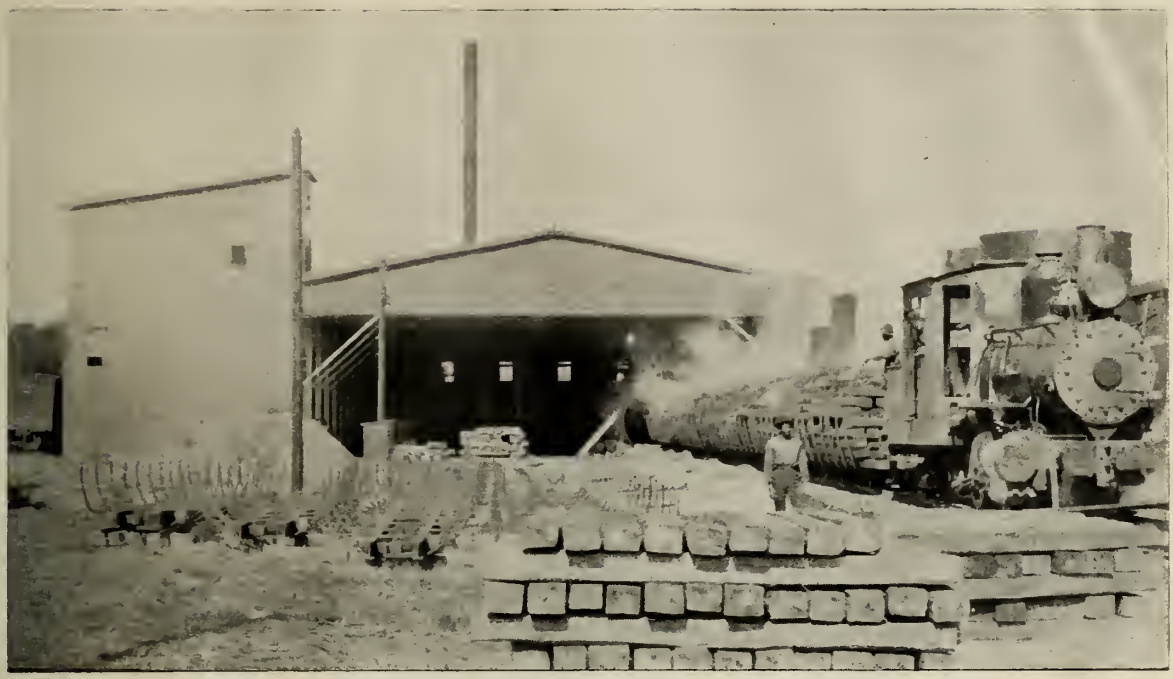
THE OPEN HEAD OF THE SMALL CYLINDER AT TEXARKANA, TEX.

OPENING THE BIG CYLINDER AT TEXARKANA—9½ FEET IN DIAMETER BY 165 FEET LONG.

AN IDEA OF THE CAPACITY OF THE TEXARKANA PLANT CAN BE GLEANED FROM THIS VIEW.



VACUUM, STEAM AND PRESSURE PUMPS AND MEASUREMENT GAGES IN TREATING WOOD WITH PRESERVATIVES.



DRAWING A TREATED CHARGE FROM A CYLINDER AT THE TEXARKANA PLANT.

A TREATED CHARGE FROM THE BIG CYLINDER AT BEAUMONT, TEXARKANA

of time a second application of a vacuum of about 24 to 26 inches is made, and maintained for about 90 minutes. By this process the timber is saturated with water, which together with the air and water-soluble compounds, is removed by the application of the second vacuum.

A second method of seasoning the timber is accomplished by keeping the wood in a storage yard. The timbers are piled in a standard method and from eight months to one year is required to thoroughly season ties and render them fit for treatment. This is the most serious objection of this method the tying up of a large amount of money for a year. If all the railroads in this country would treat all their ties and season them by this method, there would be about 100,000,000 ties in these yards all the time, which would mean an investment of about $35,000,000 with no immediate return.

The third method of seasoning timber is kiln drying. This method is expensive and is used very little in the preparation of timbers for treating with an antiseptic.

After the timber has been thoroughly seasoned it is ready for the second step, that is to inject into the pores of the timber a preservative compound. This is either done by the open tank or close tank ~~with~~ methods already described. If the close tank method is used the injection of the preservative is done by one of the three general processes namely: "the old","the Rueping" also called "the new", and the "Creoaire".

The old process has been used very extensively, but recently many railroads have adopted the Rueping process. The first steps

in these three processes are the same, that is the charging of the retort and the seasoning of the wood. These methods differ however in the injection of the antiseptic.

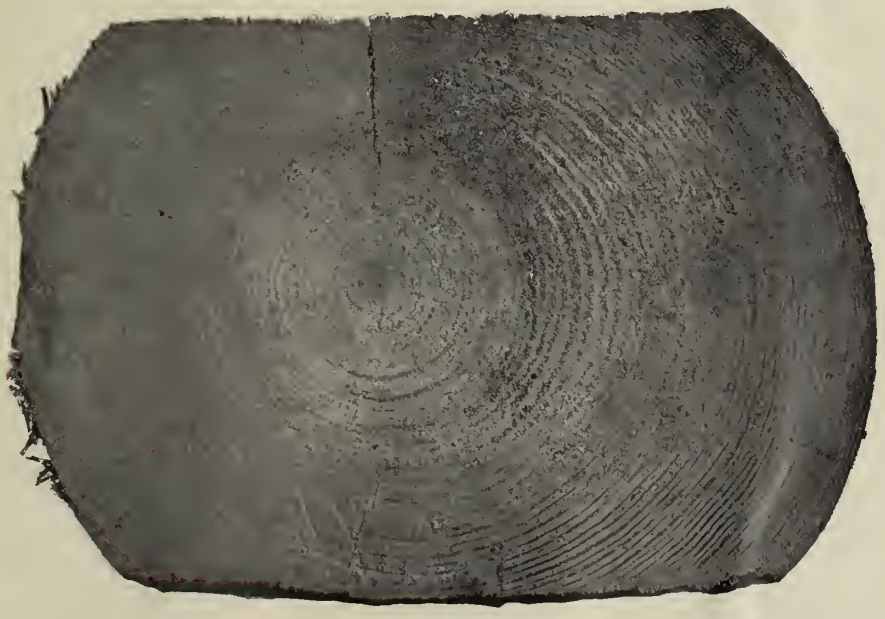
In the old process the first steps after the seasoning of the timber or ~~ex~~charging of the retort is to apply a vacuum and allow the preservative to flow in. The oil pressure pump is started as soon as the timber is entirely submerged and is kept in operation until the oil in the cylinder is under a pressure of from 100 to 125 pounds per square *inch*. The temperature of the antiseptic is maintained at from 165 to 180 F. by means of the steam pipes in the retort already described. The impregnation being accomplished, the surplus preservative in the retort is drained into a storage tank, and the timber load is then drawn from the cylinder. This process when artificial seasoning is used requires from eight to forty-eight, usually from eight to twelve, hours depending upon the kind and size of the timber, and the required amount of oil per cubic foot. The operation when artificial seasoning is used consists essentially in the following actions:

1. Charging buggies, placing in retort, closing door.
2. Steaming not over 20 lbs. pressure.
3. Producing vacuum of 18 to 24 inches.
4. Introducing solutions and applying pressures.
5. Forcing surplus solutions back into tanks.
6. Opening door of retort and withdrawing charge.

The Rueping or new process for impregnation of timber, is by no means intended for impregnating wood with a new antiseptic. The principal object of this process is to make the impregnation of

wood possible with such preservatives that have already proved to be practically the best, but which on account of their high price could not up to the present time be used very extensively. In order to impregnate by this process no special machinery is necessary, any kind of impregnating works constructed to modern demands, and used for the usual process would be sufficient. In the old method the pores and other cavities are entirely filled with the preservative, while in the Rueping process the wood cells are intended to remain more or less empty, and only their walls are to be coated or saturated with the preservative. In the Rueping process the seasoned wood is subjected for some time, for about half an hour to one hour, to an air pressure of about 60 to 65 lbs., so that all cells must be filled with compressed air. This is the principal difference between the old and the new method; with the former the air is removed from the wood cells by a vacuum, whereas on the contrary with the latter, the wood is filled with compressed air, the other steps of the processes are the same. It may also be stated that by applying a vacuum after the wood has been treated, from 5 to 10 per cent of the impregnating fluid left in the wood may furthermore be regained. This method can be used for any preservative and many railroads are now treating their ties with creosote oil by this process. Samples of timbers treated by this process are shown in cuts on pages 28 & 29

CROSS SECTION FROM THE MIDDLE OF LONG LEAF PINE TIE TREATED AFTER RUEPING PROCESS AT SOMERVILLE, TEX.



CENTER CROSS SECTION OF SHORT LEAF PINE TIE TREATED AFTER RUEPING PROCESS AT SOMERVILLE, TEXAS.

CENTER CROSS SECTION OF GERMAN TELEGRAPH POLE OF BALTIC PINE TREATED AFTER THE RUEPING PROCESS.

No. 10.—TREATED SHORTLEAF PINE TIE AFTER FIVE YEARS' USAGE.

CREOAIRE PROCESS.

The principal object of the Creoaire process is like that of the Rueping process, in that it is intended to reduce the amount of preservative used. That is to thoroughly penetrate the whole body of the timber without the use of an excess amount of preservative. This method has been exclusively used in the creosote process, and consists of injecting the desired number of pounds of oil per cubic foot of wood, and then by powerful air pressure cause the preservative to penetrate the wood to a greater depth. This method has not been used very much but has been found very effective.

CREOSOTING.

The creosoting process consists of injecting into the timbers hot creosote oil also called dead oil of coal tar, in a closed cylinder under pressure. It was invented by John Bethell, an Englishman, in 1835. The earliest attempt at real creosoting in the United States was made in 1865 for the Old Colony Railroad. Creosoting is without doubt the most efficient method of preserving timber. It is also the most expensive, and for this reason perhaps more than any other, it has failed to be extensively adopted in America. Creosote is the only material, which will effectually protect timbers submerged in certain ocean waters from the teredo. Where timbers are intended to withstand the ravages of the teredo off the coast of Florida, and in the Gulf of Mexico, as well as on the Pacific coast, should contain about twenty to twenty-four pounds per cubic foot of a good quantity of oil. Timbers for similar use in northern waters will prove satisfactory with a lighter

treatment of oil, say from twelve to eighteen pounds per cubic foot. The creosote oil is a distillate from coal tar.

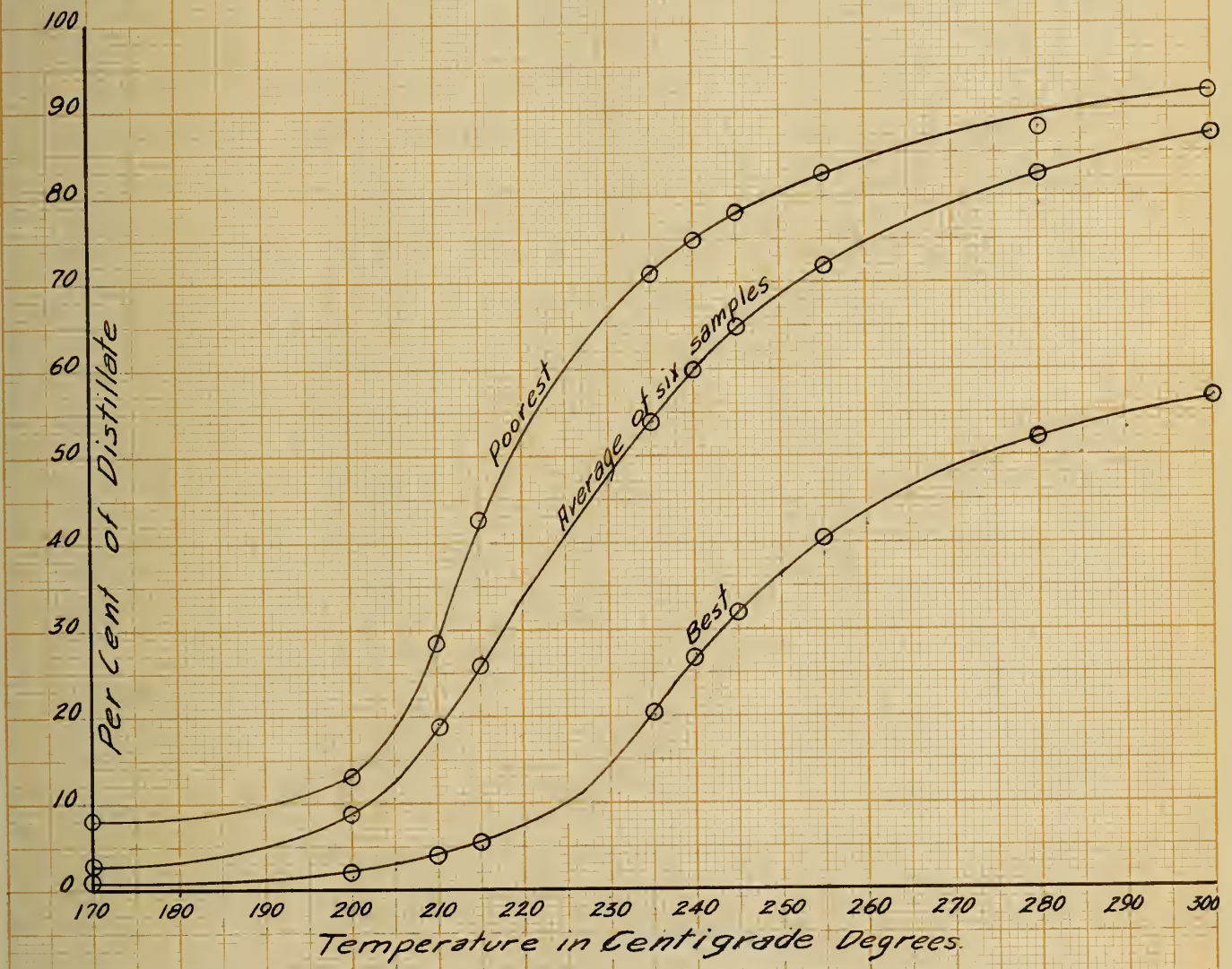
The present consumption of creosote oil is growing to be enormous and the prices are advancing accordingly. The production of creosote oil in this country in 1905 amounted to about 8,612,500 gallons. To this must be added the importation of 7,750,500 gallons, making the total consumption of creosote oil in this country in 1905 about 16,363,000 gallons. This is an increase of almost 100 % over the previous year, and is about four times the amount for 1903.

SPECIFICATIONS OF COAL TAR OIL.

Recent investigations upon coal tar oil have led to the conclusion, that the actual chemical composition of the constituents of a creosote oil is of minor importance in securing the indefinate preservation of timber, as compared with the constituents which have high boiling points and so guarantee the greatest possible stability. The reduction of the low boiling fractions is desirable, as much as possible consistent with obtaining an oil which will be fluid enough at all working temperatures. These specifications should aim to secure, leaving out the question of the chemical properties of components, and dwelling upon the necessity for obtaining fractions of a high boiling character as determined by fractional distillation. Little faith can be put upon the specific gravity of creosote oil as it can be easily increased by the addition of pitch. However the good oils have a specific gravity of about 1.02 to 1.08 between the temperatures of 35 and 45 degrees centigrade. A very good specification for coal-tar creosote was proposed some years ago by Messrs.

von Schrenk, Fulks, and Kammerer and is as follows: "The oil used shall be the best obtainable grade of coal tar creosote; that is, it must be a pure product of coal tar distillation and must be free from admixture of oils, other tars or substances foreign to pure coal-tar; it must be completely liquid at 38 deg. Cent., and must be free from suspended matter; the specific gravity of the oil at 38 deg. Cent. must be at least 1.03. When distilled according to the standard method, that is, using an 8 oz. retort, asbestos covered, with standard thermometer, bulb 1/2 inch above the surface of the oil, the creosote calculated on the basis of the dry oil, shall give no distillate below 200 deg. Cent., not more than 5 % below 210 deg. Cent., not more than 25 % below 235 deg. Cent., and the residue above 355 deg. Cent., if it exceeds 5 % in quantity must be soft and plastic. The oil shall not contain more than 3 % water." These specifications are rather rigid as can be seen from the curves on page 33 which show the best, the poorest and the average of six specimens. The usual specifications will follow the average curve very closely and oil which will fullfil these conditions is considered very good indeed.

Curves Showing Distillates from Creosotes



U OF I S. S. FORM 1

BURNETTIZING PROCESS.

Burnettizing was introduced by Sir William Burnett, in 1838. This process consists of destroying the tendency of certain vegetable and animal substances to decay, by injecting into the wood, zinc chloride dissolved in water. The zinc chloride solution varies in strength, the inventor recommended a solution of 1 part by volume to fifty parts of water. This degree of strength is still used very much but in the Rueping process, which has been described, a solution of 1 part zinc chloride to 25 parts of water is used. Burnettizing is used exclusively for railroad ties and has been largely used by railroads in the Southern States. This system of preserving timber costs about 1/3 compared with impregnation with creosote, which is the principle cause of its wide usuage. The method of impregnating the wood under a pressure of 100 to 120 pounds per square inch, as is done in the creosoting process, is most commonly used. On account of the fact that the zinc chloride is leached out quite readily in wet sections, the treatment was somewhat modified.

The first modification was made by Mr. Wellhouse's process introduced in 1879 in St. Louis Mo. This process differs from the Burnettizing process, only by adding to the chloride of zinc a small amount of glue, followed by a solution of tannin. The effect of the tannin is to form with the glue an artificial leather, insoluble in water, which will close up the ducts and retain the zinc chloride. Another modification of the Burnettizing method was invented by Julius Rutgers of Germany. This process consists of injecting creosote with a solution of zinc chloride. It is quite efficient, and has the advantage of being less expensive than straight creosote. The

Allardyce method was conceived by the manager of the International Creosoting and Construction Company, of Galveston, Texas. This process differs from the Rutger's process in that it consists of separate injections of zinc chloride and of creosote. In this process a solution of 2 to 3 per cent chloride of zinc in proportion of twelve pounds to the cubic foot is injected. This is followed by a second injection of three pounds of dead oil of coal tar to the cubic foot. The idea of this process is to have the greater part of the oil, which is a superior preservative, remaining in the wood around the outer surface, thus producing practically a water-proof coating when allowed to vulcanize before being used. This process has been very extensively used in recent years in treating ties, sills, poles and other timbers coming in contact with the earth. Timbers treated by this method have not had a very long practical test but apparently this process is proving very satisfactorily.

CREO-RESINATE PROCESS.

This process is controlled and used by the United States Wood Preserving Company of New York, it is exclusively used for the treating of wooden blocks used for pavements. The Creo-Resinate process differs from the ordinary creosoting process in that instead of using live steam for seasoning the wood, dry heat is applied at a temperature of 250° F., and under pressure of one hundred pounds to the square inch. The heat and pressure are held until the center of the blocks, which are 4 by 4 by 8 inches, reaches 212 degrees F., thereby destroying all germ life in the timber, which is the chief cause of decay. The heat is then reduced to 150 degrees, after which a vacuum of 26 inches is created, under which the cylinder is run full of creo-resinate mixture, which consists of 50 percent creosote oil, 48 percent resin and 2 percent formaldehyde. Pressure is then applied which forces the mixture into the blocks until 22 pounds per cubic foot have been absorbed. The blocks are then run into another retort and treated with a solution of lime at a temperature of 212 degrees F., and under pressure of 150 pounds to the square inch. They are allowed to cool off gradually and then are ready for the market.

Several very good authorities after examining specimens of paving blocks treated by this process say that apparently this method is very suitable for this purpose.

KYANIZING.

This process was invented and introduced into England in 1832, by John Howard Kyan. It consists of steeping the wood in a solution

of bichloride of mercury, and the degree of dilution is usually one pound of the salt to ninety-nine pounds of water. It is a very slow process compared with those in which the wood is impregnated under pressure, and requires about as many days for treatment as creosoting or burnettizing would require hours. The usual method is to allow the timber to steep in vats for a length of time, depending upon its least thickness. Bichloride of mercury, which is the antiseptic in this process, contains muriatic acid, which acts upon iron and it is found impracticable to attempt to impregnate the wood under a pressure in iron cylinders, as can be done when other methods are used. The slow process and the great cost of the preservative have been the chief causes for this method to be abandoned.

Many other processes are used, most of which used the close tank method. The most important processes in use are:

1. Creosoting, using heavy oil of coal-tar.
2. Burnettizing, using zinc chloride.
3. Kyanizing, using bichloride of mercury.
4. Wellhouse, using zinc chloride, glue and tannin.
5. Allardyce, using zinc chloride and creosote.
6. Boucherizing, using copper sulphate.
7. Thelmany, using copper sulphate followed by barium chloride.
8. Hasselman, using copper sulphate, iron and aluminum.
9. Creo-Resinate, using creosote, resin, formaldehyde and lime.
10. Hazen, using zinc chloride and gypsum.
11. Woodbine, using surface application of substance containing creosote.
12. Vulcanizing.

A wide range of experience in treating timber for the purpose of preservation from decay, or at least for prolongation of its life by resistance of decay, has taught that the physical structure and condition of the timber is important in connection therewith. Below is a list showing the extent to which various woods may be successfully treated.

Beech..... sapwood perfectly, heart of young good, and of red heart old not at all

Birch..... good

Hard maple.... perfectly but hard to treat

Soft maple.... perfectly, but it is of no service

Red oak family perfectly

Sycamore..... perfectly but unsuited for ties on account of its brittleness

Black gum.....perfectly, tough but soft

Sweet gum..... sap perfectly, red heart difficult

Red elm ..... perfectly, tough and soft

White elm..... perfectly, not strong enough for ties

Rock elm .....perfectly, hard and strong.

Hickory ..... perfectly, good ties

Ash ..... perfectly, good ties

Loblolly pine..perfectly

Short leaf pine. sap perfectly, heart not good

Black pine.... perfectly

Long Leaf Yellow pine...cannot penetrate heart

Tamarack..... sap perfectly, cannot penetrate heart

COST OF TREATMENT.

The average cost of the various processes is shown by the tables below.

Statement Showing Cost of Creosoting Material at the Southern Pacific Company Wood Preserving Works for the Year Ending June 30, 1902.

At Oakland, Cal.

Months 1901-1902	Cu.F.T. Treated	Absorption per cu.ft. in lbs	Cost of Treatment per cu.ft. in cents.					
			Oil	Fuel	Labor	Maintenance	Oil, Waste & Water	Total
July	69,094	10.05	16.150	0.900	1.945	0.144	0.060	19.200
August	32,715	9.80	14.810	0.096	2.003	0.792	0.036	18.810
Sept.	9,353	10.05	15.220	0.935	2.519	0.312	0.072	23.850
Oct.	Not in operation.							
Nov.	45,430	10.05	15.070	0.852	2.015	0.288	0.060	19.700
Dec.	76,066	9.89	14.730	0.876	1.715	0.288	0.048	17.660
Jan. 1902	69,997	10.05	14.960	0.864	1.641	0.828	0.060	18.370
Feb.	Not in operation							
March	Not in operation							
April	39,873	10.05	14.940	1.044	2.330	2.292	0.096	20.700
May	8,230	10.05	15.820	0.780	1.476	6.210	0.144	35.200
June	Not in operation							
Total	350,843	10.05	15.170	0.924	1.920	1.092	0.060	19.150
At Latham, Ore.								
June 1902	17,384	10.32	15.390	0.732	4.680	0.012	0.024	20.850

Statement of Cost of Burnettizing Cross Ties for Southern Pacific Company for the Year Ending June 30, 1902.

At Dietze, Cal. (Portable Plant)

Months 1901-1902	Number of Ties Treated	Absorption of Zn. Cl.	Cost of Treament per Tie in Cents.				
			Zn. Cl.	Fuel	Labor	Maintenance	Total.
July 1901	(7x8) 49,052						
	(6x8) 9,775	.60	4.58	1.47	2.82	.57	9.44
August	(7x8) 113,423						
	(6x8) 16,300	.60	3.78	.58	3.09	.10	7.54
Sept.	(7x8) 96,096						
	(6x8) 11,193	.60	3.72	.05	3.22	.12	8.11
Oct.	(7x8) 99,302						
	(6x8) 19,412	.60	3.85	.68	3.00	.09	7.72
Nov.	(7x8) 91,184						
	(6x8) 10,049	.60	3.90	1.29	3.12	.09	8.40
Dec.	(7x8) 42,455						
		.60	4.07	.41	3.13	.67	8.26
Total	558,319	.60	3.89	.88	3.08	.19	8.05
Cost of moving and setting up.							.25
							8.30
At Latham, Ore. (Portable Plant)							
Jan. 1902	(6x8) 8,903						
	(7x8) 97,777	.60	3.73	.84	2.79	.12	7.39
Feb.	(6x8) 75,397						
	(7x8) 21,267	.60	3.65	.73	2.60	.16	7.74
April	(6x8) 62,324						
	(7x8) 53,490	.60	3.78	.08	2.43	.37	6.66
May	(6x8) 49,023						
	(7x8) 69,815	.60	2.69	.69	2.42	.08	5.87
June	(6x8) 20,540						
	(7x8) 38,142	.60	4.51	---	3.42	.70	8.63
Total	496,776	.60	3.57	.51	2.63	.24	6.95
Cost of moving and setting up.							.32
							7.27

These prices will vary depending upon local conditions. The usual charge made by treating works for treating is for,

Burnettizing		$7.00 per M. ft. B.M.	or 8.4 cents per cu. ft.
Allardyce		12.00 " "	" 14.4 " " "
Creosote	10 lbs. per cu. ft.	17.00 " "	" 20.2 " " "
	12 " " "	19.00 " "	" 22.8 " " "
	24 " " "	36.00 " "	" 43.2 " " "
(Rueping)	5 " " "	12.00 " "	" 14.4 " " "

The high cost of creosote accounts for the many efforts to secure the same results with other materials, or with combinations with other materials, which will reduce the amount of tar oil required. One way of doing this is to put less oil in the timber, and this accounts for the Rueping and Creoaire processes, both of which use about 5 lbs. of oil per cu. ft. The Sante Fe Railway used burnettized ties for about 20 years, but during the last few years this road has been experimenting on ties treated by the Rueping process, which has been found very satisfactorily.

LIFE OF TREATED WOOD.

The question of the life of treated or untreated timber depends entirely upon local conditions. In certain sections of Texas an untreated loblolly pine tie will not last a year, and burnettized ties will not last more than 3 or 5 years. Untreated piles in teredo water will sometimes be destroyed in a month, while piles treated with 20 lbs. of creosote per cu. ft. have lasted 35 years and still are in very good condition. This is shown in cuts on pages 5,6&7. The life of the same timber in one section of the country may or may not be (and usually it is not) the same, when exposed to the

climatic conditions in another section.

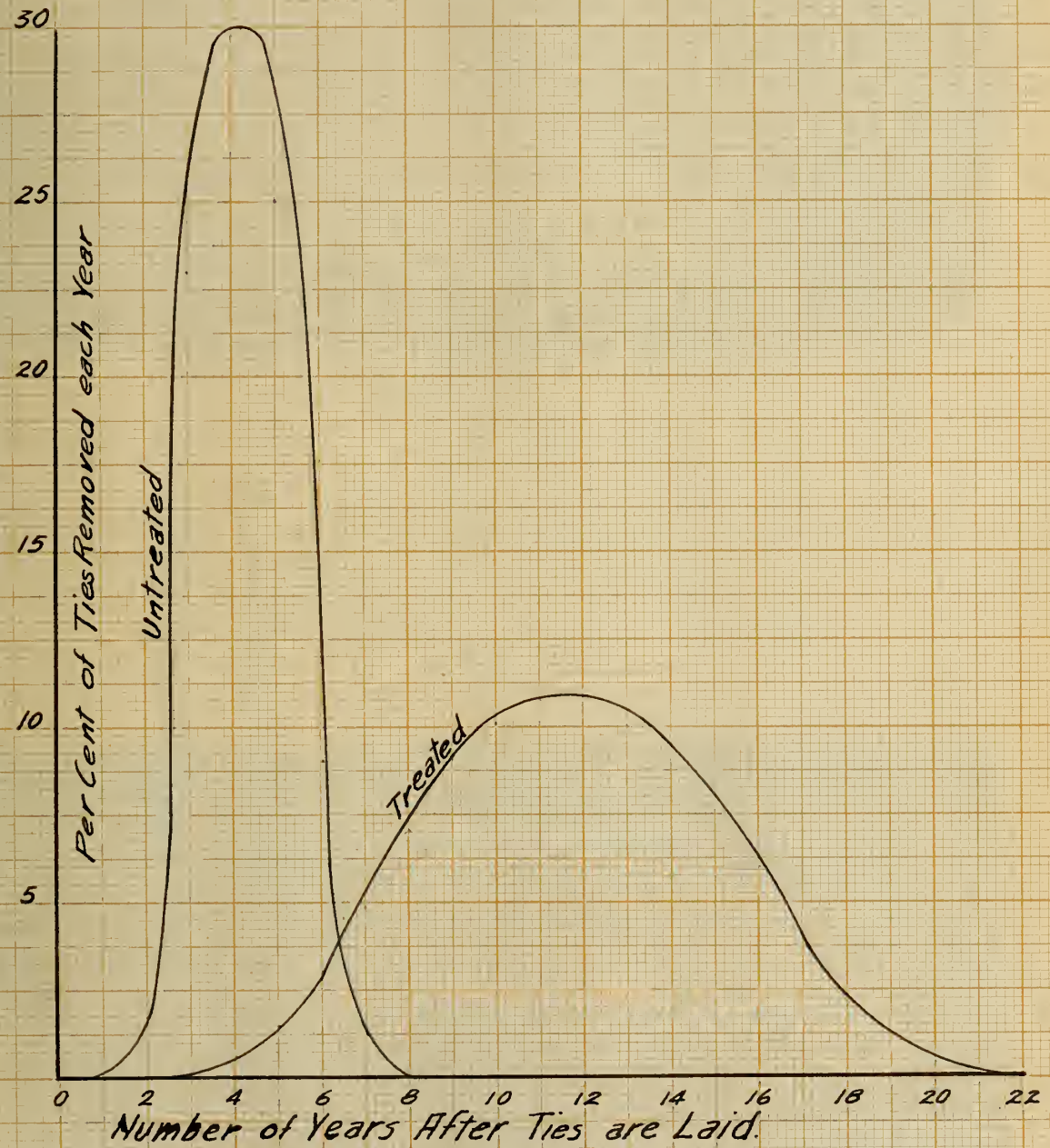
Records kept on 5,000,000 ties on the Santa Fe Railway, prove that pine ties (long-leaf, short leaf and loblolly), when properly treated with Zn. Cl 2 or with Zn. Cl 2 and glue, had average lives of 11.5 years, while the life of an untreated pine tie is about 4.2 years, this is shown in tables and diagram on pages 43 & 44 also in cuts on pages 8, 9, 10, 28 & 29. Samples of ties and piles both untreated and treated are shown in the article on causes of decay on pages 8, 9, 10, 5, 6, 7, 28, & 29.

The life of paving blocks is prolonged by proper treatment. On page 45 is a sideview taken from a cypress paving block which was treated with 12 pounds of dead oil per cubic foot and laid in New Orleans in March, 1871, and removed December, 1902. An end view of the same block is shown on page 45, and the effect of years of heavy traffic can be seen from the illustration. Gravel, shells and other foreign matter have been forced into the top of the block by traffic. The block is perfectly sound and would last many years more. This result can only be obtained by properly seasoning, and impregnating the wood with chemicals that will prevent decay, and disintegration of the wood cells. On page 46 is shown a cypress block untreated, laid in Galveston in 1836 and removed in 1898, at which time it was necessary to repave the street owing to the decayed condition of the blocks. A sample of a treated long-leaf pine paving block removed after 28 years service in Galveston, Texas is shown on page 47. The question today does not seem to be whether the treatment will prolong the life of timber or not, but how much money can we spend upon the treatment and still have economy.

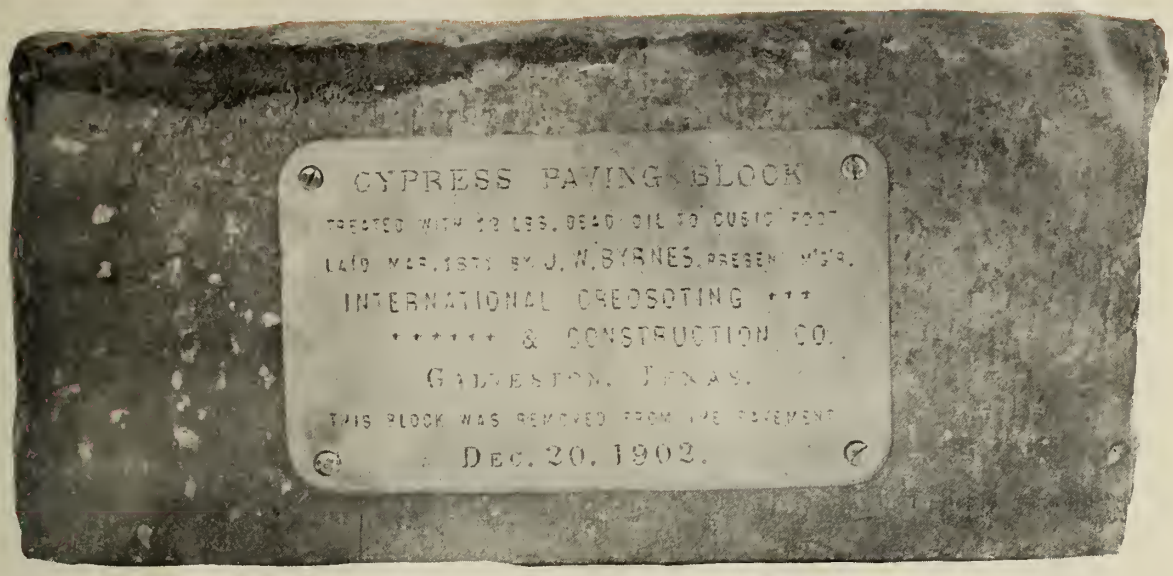
Rate of Renewals of Treated Ties Wellhouse Process A.T. & S.F. Ry.

Date Treated	Number Treated	Date of Renewal											Should be Renewed	In Yet.	No. of Years in Track	Per Cent Remain.
		1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900				
1885	111,503	780	2230	6690	8586	9478	10370	10816	10035	8920	10816	7805	86256	25247	15	22.6
1886	333,298		333	6666	19998	25664	28330	30997	32330	32330	29997	26664	233309	100,099	14	33.3
1887	189,386			1325	3788	11363	14583	16098	17613	19170	19170	17045	120155	69231	13	36.5
1888	285,104				1996	5702	17106	21953	24234	26515	27655	27655	152316	132288	12	46.6
1889	169,174					1884	3384	10150	13026	14380	15733	16410	74967	94207	11	55.6
1890	35,600						240	712	2136	2752	3026	3310	12176	23424	10	65.8
1890B	7,153						50	143	429	551	608	665	2446	4707	10	65.6
1891 B	128,568							900	2571	7714	9900	10928	32013	96555	9	75.1
1892	137,771								964	2755	8266	10608	22593	115178	8	83.6
1892B	49,499								347	989	2970	3465	7771	41728	8	84.3
1893	178,167								356	1247	3563	10690	15856	162,311	7	91.1
1894	247,566		Note: B Ties Burnettized.								3466	4951	8417	239,149	6	96.6
1895	256,877										513	1898	2411	254,466	5	99.0
1896	336,070													336,070	4	100.0
1897	380,523													380,523	3	100.0
1898	350,337													350,337	2	100.0
1899	460,382													460,382	1	100.0
1900	151,997													151,997	0	100.0
Total	3,720,438															

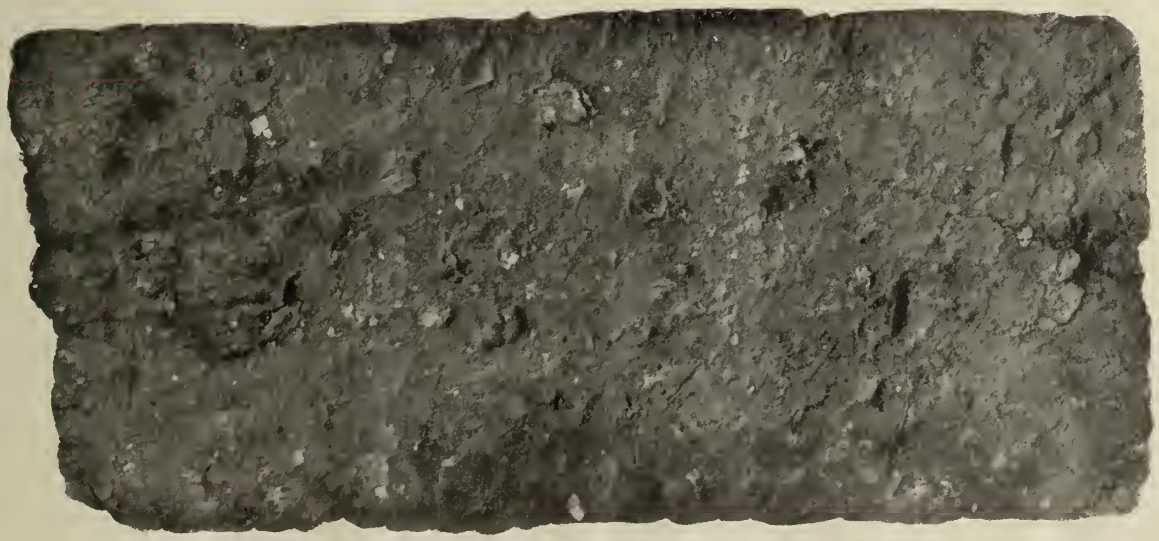
Curves Showing Relative Per Cent of Cross Ties Removed.



U OF I S S FORM 1


CYPRESS PAVING BLOCK
TREATED WITH 22 LBS. DEAD OIL TO CUBIC FOOT
LAID MAR. 1ST, 1871 BY J. W. BYRNES, PRESENT M'G'R.
INTERNATIONAL CREOSOTING ***
****** & CONSTRUCTION CO.
GALVESTON, TEXAS.
THIS BLOCK WAS REMOVED FROM THE PAVEMENT
DEC. 20, 1902.

No. 6.—CYPRESS PAVING BLOCK, USED FOR THIRTY-TWO YEARS.



No. 7.—END VIEW OF CYPRESS PAVING BLOCK SHOWN IN CUT No. 6.

No. 12.—UNTREATED CYPRESS PAVING BLOCK AFTER TWELVE YEARS' SERVICE.

No. 8.—LONGLEAF PINE PAVING BLOCK AFTER BEING USED TWENTY-EIGHT YEARS.

No. 9.—END VIEW OF BLOCK SHOWN IN CUT No. 8.

ECONOMIC CONSIDERATIONS.

The questions involved in any comparison between the ultimate cost of treated, and untreated timbers must be resolved into a comparison between the annual charges made against these timbers. The features involved are the original cost, the length of life, the cost of renewal, and compound interest on the investment. The rate of interest is immaterial, since any comparison must be made at the same rate.

Let C = original cost of timber

n = life of timber in years

A = annual payment, with compound interest, which if placed aside, will amount to sufficient to replace (at cost of C) the timber at the end of n years

r = rate of interest on initial cost

For convenience of comparing the cost of timber, a tie will be considered. A payment of C is made when the tie is installed. A second payment of C is made at the end of n years. The present value of this second payment is $\frac{C}{(1+r)^n}$, and the present value of the third payment which is made at the end of $2n$ years is $\frac{C}{(1+r)^{2n}}$; then the total present value of the investments will be equal to

$$C + \frac{C}{(1+r)^n} + \frac{C}{(1+r)^{2n}} + \text{----------}$$

Suppose the annual payment, A, is made at the end of each year. The present worth of these payments is as follows:

For the first payment, $\frac{A}{(1+r)}$

For the nth. payment, $\frac{A}{(1+r)^n}$

which annual payments represents the present worth of the tie during its life of n years.

When the tie is replaced, after n years, the present value of the payments on this replaced tie will be:

For the n+1 payment, $\frac{A}{(1+r)^{n+1}}$

For the 2 n *th* payment, $\frac{A}{(1+r)^{2n}}$

which represents the present worth of the payments to be made on the second tie. When this tie is replaced by a third tie at the end of 2n years, the present value of the 3n th payment against this third tie is equal to $\frac{A}{(1+r)^{3n}}$

The present value of the cost (C) will be equal to the present value of the annual payments charged up against these ties as long as the series is continued, i.e.,

$$C + \frac{C}{(1+r)^n} + \frac{C}{(1+r)^{2n}} + \text{---------} = \frac{A}{(1+r)} + \frac{A}{(1+r)^2} + \text{--------} + \frac{A}{(1+r)^n}$$
$$+ \frac{A}{(1+r)^{n+1}} + \frac{A}{(1+r)^{n+2}} + \text{------} + \frac{A}{(1+r)^{2n}}$$
$$+ \frac{A}{(1+r)^{2n+1}} + \frac{A}{(1+r)^{2n+2}} + \text{----} + \frac{A}{(1+r)^{3n}}$$

$$\therefore \frac{C(1+r)^n}{(1+r)^n - 1} = \frac{A}{r}$$

$$\text{or} \quad A = \frac{r \times C \times (1+r)^n}{(1+r)^n - 1}$$

The annual charge A', against renewals must also be considered. No money is paid out until the tie is renewed at the end of n years. Annual charge (A') against such renewal would be

$$A' = \frac{C' \times r}{(1+r)^n - 1}$$

in which C' is the cost of renewal, and r is the rate of interest.

For convenience in making a comparison of the relative annual charges against timber of known cost and life, tables on pages 51&52 in which these various charges are stated, have been prepared. The interest in both tables is compounded at 4 percent. For instance, a tie costing 50 cents, and lasting ten years has an annual charge against it of 6.17 cents. If it cost 20 cents for relaying, the annual charge against it will be 1.66 cents making a total annual charge of 7.83 cents. Suppose a tie cost 45 cents, and the life of this tie is 6 years. The question is, how much can be expended on treating it, by so doing, the life is extended to fourteen years? The annual charge against the untreated tie is 8.59 cents, to this must be added the annual charge for renewal of 3.02 cents provided it cost 20 cents to relay, making a total annual charge of 11.61 cents. If 50 cents was added in preservatives, this tie would have to last about 12 years-the annual charge against the 95 cent tie, including renewal, being 11.46 cents.

One important consideration in this connection must not be lost sight of. The mechanical wear of the tie must always be carefully considered. Of course it is not a paying proposition, to add to the cost of a tie by preservation processes to such an extent that the ties preserved from decay for years after its mechanical destruction. One of our great railway systems, has made the following statement, " that if a treated tie lasted twice as long as an untreated tie, the cost of the former might be 30.53 percent greater than the cost of the untreated tie". Similar calculations can be made on other timbers, such as piles, wooden block for pavements, bridge timbers etc., by the same reasoning.

Table — Showing Annual Charge against a 3 cu. ft. Tie, if Original Cost and Life of Tie are Known.
The Interest on the Original Cost is Compounded at 4 Per Cent.

Original Cost of Tie	Life of Tie in Years																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cents.	Cents	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Cents
20	7.21	5.51	4.50	3.82	3.33	2.97	2.69	2.47	2.28	2.13	2.00	1.90	1.80	1.72	1.65	1.58	1.52	1.47
25	9.01	6.87	5.62	4.77	4.17	3.71	3.37	3.08	2.85	2.66	2.50	2.38	2.25	2.15	2.06	1.98	1.90	1.84
30	10.81	8.26	6.74	5.72	5.00	4.46	4.04	3.70	3.43	3.20	3.01	2.85	2.70	2.57	2.47	2.37	2.28	2.21
35	12.61	9.64	7.87	6.68	5.83	5.20	4.71	4.32	4.00	3.73	3.51	3.33	3.15	3.00	2.88	2.77	2.66	2.57
40	14.41	11.02	8.99	7.63	6.66	5.94	5.38	4.93	4.57	4.26	4.01	3.80	3.60	3.43	3.29	3.16	3.05	2.94
45	16.21	12.39	10.11	8.59	7.50	6.69	6.06	5.55	5.14	4.80	4.51	4.28	4.05	3.86	3.70	3.56	3.43	3.31
50	18.01	13.77	11.24	9.54	8.33	7.43	6.73	6.17	5.71	5.33	5.01	4.75	4.50	4.29	4.11	3.95	3.81	3.68
55	19.81	15.15	12.36	10.49	9.16	8.17	7.40	6.79	6.28	5.86	5.51	5.23	4.95	4.72	4.52	4.35	4.19	4.05
60	21.61	16.52	13.49	11.45	10.00	8.91	8.08	7.40	6.85	6.40	6.01	5.70	5.40	5.15	4.93	4.74	4.57	4.41
65	23.42	17.90	14.61	12.40	10.83	9.66	8.75	8.02	7.42	6.93	6.51	6.18	5.85	5.58	5.34	5.14	4.95	4.78
70	25.22	19.28	15.73	13.36	11.66	10.40	9.42	8.64	7.99	7.46	7.01	6.65	6.30	6.01	5.75	5.53	5.33	5.15
75	27.02	20.66	16.86	14.31	12.50	11.14	10.10	9.25	8.56	7.99	7.51	7.13	6.75	6.44	6.17	5.93	5.71	5.52
80	28.82	22.03	17.98	15.26	13.33	11.89	10.77	9.87	9.14	8.53	8.02	7.60	7.20	6.86	6.58	6.32	6.09	5.79
85	30.62	23.41	19.11	16.22	14.16	12.63	11.44	10.49	9.71	9.06	8.52	8.08	7.65	7.29	6.69	6.72	6.47	6.25
90	32.42	24.79	20.23	17.17	14.99	13.37	12.11	11.10	10.28	9.59	9.02	8.55	8.10	7.71	7.40	7.11	6.85	6.62
95	34.22	26.16	21.35	18.13	15.83	14.12	12.79	11.72	10.85	10.13	9.52	9.03	8.55	8.41	7.81	7.51	7.23	6.99
100	36.02	27.54	22.48	19.08	16.66	14.86	13.46	12.33	11.42	10.66	10.02	9.50	9.00	8.58	8.22	7.90	7.61	7.36
For each additional 5 cents to the cost add	1.801	1.377	1.124	0.954	0.833	0.743	0.673	0.617	0.571	0.539	0.501	0.475	0.450	0.429	0.411	0.395	0.381	0.368

Table — Showing Annual Charge Against Tie for Relaying, if Cost of Relaying and Time are Known
The Interest on Cost of Relaying is Compounded at 4 Per Cent.

Cost of Relaying	Time of Relaying, in Years.																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cents	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Cents
10	3.20	2.35	1.85	1.51	1.27	1.08	0.95	0.83	0.74	0.67	0.60	0.55	0.50	0.46	0.42	0.39	0.36	0.34
15	4.80	3.53	2.77	2.26	1.90	1.62	1.42	1.25	1.11	1.00	0.90	0.82	0.75	0.69	0.63	0.58	0.54	0.50
20	6.41	4.71	3.69	3.02	2.53	2.16	1.89	1.66	1.48	1.33	1.20	1.09	1.00	0.92	0.84	0.78	0.72	0.67
25	8.01	5.89	4.62	3.77	3.17	2.71	2.36	2.08	1.85	1.66	1.50	1.37	1.25	1.15	1.06	0.97	0.90	0.84
For each additional cent add	0.320	0.235	0.185	0.151.	0.127	0.108	0.095	0.083	0.074	0.067	0.060	0.055	0.050	0.046	0.042	0.039	0.036	0.034

STRENGTH OF TREATED TIMBER.

Timber is frequently injured by excessive steaming, or by high temperature either during the steaming process or during the injection of the preservative. Steaming above the boiling point of water is a serious injury to the wood, destroying the elasticity of its fiber, making the wood particularly liable to break under impact. In the experimental tract laid in 1902 in Texas, some of the creosoted ties broke in half in the track after a few months of service. Some of these ties were so brittle that they broke on being thrown from the car to the ground. These ties had been subjected to an excessive temperature during the steaming process, and also during the injection of the creosote.

The effect upon steaming and treating timber, is shown by the results of experiments made by the Bureau of Forestry U. S. Department of Agriculture. The test pieces of these experiments were 11 feet long, and were cut at the same time from one forest site. In testing the influence of the seasoning process, a three foot section was cut from one end of each timber and sawed up in test pieces, which furnished a basis of comparison between the results of tests on these pieces, and the results on pieces taken from the remaining 8 foot section, after the latter had been subjected to the various seasoning processes in the treating cylinder. In testing the effect of preservatives themselves the entire 11-ft. timber was subjected to the preliminary seasoning processes, after which a three foot section was cut from the end of each timber. The 3 foot section thus having been subjected to the seasoning processes formed a basis of comparison with the remaining 8 foot section, which was treated with preservatives. In this way the separate effects

of the preliminary processes and the effects of the preservatives could be determined.

The test pieces were subjected to cross-bending strain, compression along the grain under both static and impact conditions, and under shearing parallel to the grain, and compression at right angles to the grain under static conditions. Ordinarily the strength tests were made immediately after treatments in the cylinder. These experiments indicate that the steaming process weakens the resistance of the wood fiber to both static and impact loadings. It may be stated that this diminution of strength, is very nearly in direct proportion to the length of time that any given steam pressure is applied. The diminution of strength was found to be 25 % after a pressure of 20 pounds was applied for ten hours to green loblolly pine, and 10 per cent when a pressure of twenty pounds was applied for 4 hours. This diminution of strength increased very rapidly when the pressure rose above 20 pounds, and amounted to about 25 percent when a pressure of 50 pounds was applied for 4 hours. The average decrease in strength is 0.125% for every pound hour of steam pressure.

Recent experiments made by Professor W. K. Hatt, show that timber subjected to steam, under pressure, shows a loss in strength, and that such loss is a fraction of the steam pressure and the duration of such treatment. Reducing all the firgures to percentage, the following results (for loblolly pine) were obtained.

Strength of unsteamed tie	100
Strength of tie steamed 4 hours at 10 pounds	89
Strength of tie steamed 4 hours at 20 pounds	84

Strength of tie steamed 4 hours at 30 pounds 75

Strength of tie steamed 4 hours at 40 pounds 76

Strength of tie steamed 4 hours at 50 pounds 68

Strength of tie steamed 4 hours at 100 pounds 41

These figures have been corrected in order that the test may be comparable, at the same degree of moisture, but no correction was made for the effect of the water in the wood.

With relation to the effect of preservatives themselves, it may be said that the treatment with zinc chloride does not seem to further reduce the strength of timber, beyond the effect of the steaming process. Under static loading the strength of timber that had been treated the 2 1/2 per cent solution of zinc chloride, after having been steamed four hours at 20 pound pressure, was the same as that of timber which had been steamed without the subsequent application of zinc chloride. It may be that subsequently the crystalization of the zinc chloride will weaken the wood fiber. This remains to be determined.

Mechanical tests made on specimens cut from loblolly pine ties treated by the Rueping process for preserving timber at Somerville, Texas, furnished by Mr. E. O. Faulkner, Manager, Tie and Timber Department, Santa Fe Railroad, shows that the strength of the treated timber by this process is greater than untreated timber. The test pieces of these experiments were ten selected 11 - ft. ties of seasoned loblolly pine. From each tie before treatment, a three foot length was sawed to furnish test specimens to determine the strength of the natural wood. The remaining 8 - foot length was treated by the straight Rueping process. The penetration of the various ties

is shown by the accompanying table.

Table showing number of pounds of creosote absorbed by ties treated by the Rueping Process.

Before Treatment.				Weights of 8ft. pieces after Treatment in lbs.				
Number	Original weight in lbs.	Weight of 8ft piece in lbs.	Weight of 3 ft piece in lbs.	December 1904				lbs. of oil per 8ft. piece
				10	12	21	29	
1	171.5	123.0	48.5	134.0	133.0	133.0	131.5	11.0
2	170.0	124.0	46.0	138.0	137.0	136.5	137.0	14.0
3	178.0	129.5	48.5	142.0	140.0	139.0	138.5	12.5
4	162.5	118.0	44.5	130.5	129.0	128.0	128.5	12.5
5	172.5	122.5	50.0	139.0	137.5	136.5	139.0	16.5
6	168.0	120.5	47.5	133.5	132.0	131.0	130.5	13.0
7	174.5	126.0	48.5	144.0	143.0	141.0	141.0	18.0
8	164.0	117.5	46.5	129.0	128.0	128.0	127.0	11.5
9	173.0	129.0	44.0	142.0	140.0	142.0	139.5	13.0
10	171.0	125.5	45.5	141.0	140.0	138.0	138.5	15.5
Totals	1705.0	1235.5	469.5	1373.0	1359.5	1353.0	1351.0	137.5
Average	170.5	123.6	47.0	137.3	136.0	135.3	135.1	13.8
Average gain in lbs				13.7	12.4	11.7	11.5	
Average gain in per cent.				11.0	10.0	9.5	9.3	

The 3 feet pieces were supposed to be seasoned and therefore were not reweighed. The treated 8 foot lengths furnished test pieces for determining the strength of the treated wood. From each length of natural and treated wood, four specimens 2 x 2 inches in cross section and 36 inches long were cut for static cross bending tests. After this test all the unfractured ends of the specimens, one 2 x 2 x 4 for compression parallel to the fiber, one 2 x 2 x 6 for compression perpendicular to the fiber, and one 2 x 2 x 3 for shear radical to the grain were cut. In cutting the specimens from the tie care was taken to select clear, straight grain pieces free from all defects. All tests under static loading and of the four following kinds; 72 cross-bending, 78 compression parallel to the fiber, 76 compression perpendicular to the fiber and 66 shearing tests along the radius of the cross section of the tree.

The summarized results of the test are shown in table, on page 58 which also contains a comparison of the results on a basis of 100 for the strength of the natural wood.

Table showing the relative strength of natural and treated wood.

	Value of treated wood in percent of natural wood.
Cross bending	
Fiber stress at elastic limit	126
Modulus of rupture	117
Modulus of elasticity	117
Compression parallel to fiber crushing strength at maximum load	130
Compression perpendicular to fiber crushing strength at yield point	114
Shear - radical Shearing stress	103

The above tests show that there is no decrease in the strength of the wood due to the Rueping process of treating timber, but on the contrary some apparent increase.

These two sets of experiments are the only mechanical tests that have been performed. The first set described were performed on wood treated by the old method of creosoting while the second set were tests made upon wood creosoted by the new or Rueping process. The results of the first indicate a decrease in strength while the results of the second set show an increase in strength. From these tests the following conclusions can be made.

(1) A high degree of steaming is injurious to wood in strength. The degree of steaming at which pronounced harm results will depend upon the quality of wood and its degree of seasoning, and upon the pres-

sure of steam and the duration of its application.

(2) The presence of zinc chloride will not weaken wood under static loading, although the indications are that the wood becomes brittle under impact.

(3) The presence of creosote will weaken wood treated by the old process, and apparently strengths the wood slightly when creosoted by the Rueping process. This may be accounted for by the fact that in the wood treated by the old process the cell walls are always kept moist by the oil in the cells, but in the wood treated by the Rueping process there is no oil in the cells, and the small amount of creosote on the cell walls soon becomes hard and strengthens the wood.

SUMMARY OF THE TIMBER PRESERVATION.

In this country, the treatment of railroad ties and timber only dates back 25 years, with a few exceptional efforts in a tentative way and in but limited quantities. The chloride of zinc and creosote, taken the lead as the agents, the former owing to the cost coming within the limit of economy has so far outstripped the use of the latter, that today scarcely one great railroad can be found using the creosoted ties, except in tests particularly ties treated with creosote by the Rueping process. Most of the largest railroad systems are fast filling their tracks with treated ties. These railroads are using either the simple chloride of zinc process or a modification, in which glue and tannin are employed as a retardent to help to conserve, and to prevent in some degree the waste of the chloride by leaching.

The records are not as perfect and complete as could be de-

sired,but even in the face of imperfect records and with indications of imperfect treatment, the zinc chloride has shown a great economy in the maintainance of the roadway. Although it is very difficult to give a rule at all generally applicable, it may however be said that there is a unanimous opinion that treating materially increases the life of ties; approximately the life is doubled in case of oak ties, tripled in that of pine and quadrupled in that of beech.

Creosote where a full impregnation can be had, has almost invariably proved effective in prolonging life of timber, and in certain lines has been resorted to where prolonged life is very essential notwithstanding the excess of cost. The use of creosoted timbers has been chiefly confined to piling, particularly to piles used in teredo waters.

The new or Rueping process, however, has brought the cost down to the line of economy, and it will no doubt be used to creosote ties. This process of course cheapens the treatment but only the lapse of considerable time will demonstrate the degree of success. As already stated in this paper the ties treated by this process, and laid in the experimental track in Texas, are still in very good condition after a service of six years.

A comparative report of timber treated in the United States for 1904, 1905 and 1906 is given in table.

Comparative Report of Material Treated in the United States
for years 1904, 1905, and 1906

Process	1904	1905	Increase	1906	Increase	Average lbs injected per cu.ft. in 1906
Creosote						
Cu.Ft piling	3,507,993	4,545,916	1,037,923	5,353,827	807,911	14
" " lumber	2,128,747	2,952,547	823,800	3,634,841	682,294	14
" " bridge timber	244,390	300,041	55,651	861,702	561,702	12
" " paving blocks	- - - -	690,769	690,769	1,764,233	1,073,464	10 to 14
" " barge material		400,000	400,000	No report		
" " cross arms				122,612	122,612	10 to 14
Net Increase			3,008,143		3,247,983	
No. of Ties Treated.	77,120	1,123,684	1,046,564	1,836,983	713,299	11
No. of Fence Posts.		14,000	14,000	No report		
Zinc Chloride						
Cu.Ft. piling	58,221	10,337	* 47,884	11,657	1,320	0.46
" " lumber	854,709	281,330	* 573,379	365,411	84,081	0.42
" " bridge timber	554,190		* 554,190	34,887	34,887	0.84
" " switch ties.		434,655	434,655	404,736	* 29,919	0.55
Net Increase			* 740,798		90,369	
No. of Ties Treated.	13,853,985	13,477,262	* 376,723	14,168,784	691,522	0.43
No. of Fence Posts	332		* 332			
Zinc and Oil.						
Cu.Ft. piling	91,974	130,610	38,636	211,563	80,953	Zinc 0.25 Oil 3.00
" " lumber	19,568	64,548	44,980	5,691	* 58,857	Zinc 0.25 Oil 3.00
Net Increase			83,616		22,096	
No. of Ties Treated.	149,295	418,168	268,873	918,691	500,523	Zinc 0.38 Oil 2.70

* Decrease

Report continued.

Comparative Report of Material Treated in the United States for years 1904, 1905 and 1906 (con.)

Process	1904	1905	Increase	1906	Increase	Average lbs injected per cu. ft. in 1906
Zinc, Glue, and Tannin						
Cu. Ft piling	346	33,778	33,432		*33,778	
" " lumber	21,514	23,860	2,346	6,364	*17,496	0.45
" " bridge timber		41,692	41,692	68,534	26,842	0.45
" " switch ties		32,366	32,366	37,856	5,520	0.41
Net Increase			109,836		*18,912	
No. of Ties Treated.	1,101,230	1,399,212	297,982	907,775	*491,437	0.50

*Decrease.

Recapitulation of Comparative Report of Material Treated in United States for years 1904, 1905, and 1906 (see report on pages 61 & 62)

Increase	1904–1905	1905–1906
Net increase of cu.ft. piling	1,062,107	856,406
" " " " " lumber	297,747	700,617
" " " " " paving blocks	690,769	1,073,464
" " " " " bridge timber		612,837
" " " " " barge "	400,000	
" " " " " switch ties	467,021	
" " " " " cross arms		122,612
Total " " " " of material	2,917,644	3,365,936
Net decrease " " " bridge material	456,847	
" " " " " switch ties		24,399
Total increase of cu.ft of material treated. (not including cross ties or fence posts.	2,460,797	3,341,537
Total net increase of cross ties treated	1,236,696	1,413,907
" " " " fence posts treated	13,668	No report.
Average tie = 2.7 cu.ft.		
" fence post = 2.6 cu.ft.		
Grand total net increase in cu.ft.	5,835,413	7,159,086
Total amount treated in cu.ft in United States in		
1904	1905	1906
48,465,516	54,300,929	61,460,015
Total amount timber used in United States. cu.ft.		8,300,000,000

The above summary shows a rapid increase in the amount of timber treated particularly in amount creosoted, while the amount treated by zinc chloride shows a decrease except in the treating of ties. It also shows that only about three fourths of one percent of the total amount of timber used in this country receive treatment. Of course it is not necessary to treat all of the timber we use, since a great deal of it is used for inside finishing and places where it is not exposed to decay, but it has been estimated that we could treat at least 15 percent of the timber used. It is evident that the industry of wood preservation is sure to expand great proportions and also to modify and improve the present practice.

There are a number of problems in the treatment of timber which are yet unsolved. The subject, however, has been removed beyond the experiment stage and treatment can be adopted with reasonable confidence that benefits commensurate with the expense will be secured, and that further investigations and discoveries will be in shape of developments, which will probably enable us with reasonably increased expenses, to secure more permanent and satisfactory results.

Careful records are now being kept by several railroads upon the life of treated ties. Unfortunately no such records have been kept of untreated timbers, which should be done so as to form a basis for a comparison of the treated and untreated timbers.

Within the last few years the Forest Service of the United States, and Department of Agriculture, the Wood Preserver's Association, and the Railroads have done very much in the development of the wood preserving industry, and it is expected that they will make great

discoveries, and improvements within the next ten years.

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